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Low Cost Improvement of Earth Roads With Crushed Stone

By A. T. GOLDBECK, *Director*
Bureau of Engineering
National Crushed Stone Association

The magnitude of the highway system of the United States is somewhat difficult to visualize. We are told that at the close of 1924 there were 3,200,916 miles of roads of all classes and yet of these roads 2,500,000 miles remained with no surfacing on them whatever. These, in large part, are the secondary roads which carry comparatively light traffic. Thousands of miles of highways may never need any better surfacing than provided by the natural soil; many miles, in time, will require the highest types of surfacing, while still other stretches would adequately serve traffic if given a very inexpensive dressing of small size crushed stone.

At the present time the annual expenditure for highways is approximately one billion dollars per year. If all this money were spent for the construction of the best types of pavement, costing approximately $30,000 per mile, some communities would have to wait seventy-five years or more before receiving any benefits from highway construction within their immediate vicinity. These communities not only would have to endure the disagreeable inconvenience of bad roads but they also would have to bear the greatly increased cost of motor transportation in their vicinity. Frequently, they would be forced to wait until road conditions would permit of any travel whatever. If advantage were taken of low type surface construction all of the 2,500,000 miles of unpaved roads could be given a surface that would provide a smooth road suitable for high speed, year-round, light traffic, and this could be accomplished at one-tenth the initial cost of high type surfaces.

Several of the state highway departments have seen the wisdom of low cost road improvement and the taxpayers have been delighted with the results wherever it has been tried. In several states the public has been provided with several thousand miles of roads, which can be travelled continuously at high speed and this accomplishment has been the result of only a few years of work. Previously, on many of these roads an average speed of only six miles per hour could be maintained while now the maximum speed permitted by law seems to be the rule. Had these states decided to plunge immediately into the construction of high types of surfacing, the travelling public would have been without suitable roads for many years to come in many localities.

The "Salting Down" or Dry Method of Maintaining Earth Roads

The method consists in treating the road surface with a thin layer of small size crushed material and maintaining the surface in a smooth condition by dragging at sufficiently frequent intervals. It is an extremely simple method and can be executed with the simplest kind of road building equipment. It is applicable not only to state and county systems but to driveways and farm entrance roads as well and is not intended for roads carrying over 500 vehicles per day. In no sense can it replace the highest types of surfaces.

Description of the Method

The earth road to be improved probably will need reshaping to a proper cross-section and the drainage requirements should be carefully studied and provided. A cross-section which will give good results is shown in Fig. I. Note that a very flat crown is suggested, not to exceed ¼ to ⅜ inch per foot. It is to be remembered that the finished road when properly maintained will accommodate high speed traffic and due attention should therefore be given to both line and grade as well as to super-elevation on curves.

This point cannot be too strongly emphasized for it must be assumed that traffic will some day increase sufficiently to warrant the construction of a still better surface. If the line and grade have been properly prepared the road will be ready for the better surfacing with little alteration and the subgrade will have been compacted and strengthened by the stone already used.

On the other hand, improper attention to line and grade will necessitate the building of a new grade and thou-

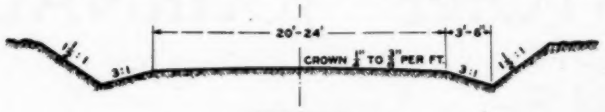

FIGURE I.
Finished Subgrade Ready for Light Surfacing of Stone.

sands of tons of stone will have been wasted. For big jobs of grade preparation, the usual grading equipment of tractors and graders, small power shovels, trucks, slip and wheel scrapers are needed in various parts of the work.

After the subgrade has been prepared, the surfacing material is spread at the rate of approximately one thousand tons per mile for the first application. The size and kind of material varies in different localities, but with crushed stone the best results have been obtained with an initial application of material passing a 1-in. screen and retained on the No. 10 sieve. After the stone is spread out of dump trucks, it is bladed to the sides of the road in windrows leaving a layer only 1 inch in thickness on the subgrade. Traffic may be immediately turned on the road and as weak places develop, additional stone is dragged in from the windrows or piles along the sides and in this manner the weak spots are kept filled and the stone surfacing becomes thoroughly compacted under traffic.

A smooth surface is maintained by dragging and the excess material is drawn in from the sides as required. It is necessary to keep a thin loose layer on the surface and for this reason it is undesirable that the stone contain any clay or material which will cause it to bond tightly together, for such material cannot be dragged successfully and rapidly develops potholes; nor must the layer of loose stone be too thick for this becomes dangerous for traffic. Not over one inch of uncompacted material is desirable as a surface layer. In time, as more and more of the stone compacts and the loose material is drawn in from the sides, the road crust gradually builds up in thickness and becomes more and more efficient for carrying loads.

Frequency of Dragging

The equipment used for dragging may be one-man power graders, sometimes followed by sled drags. Figs. II, III, IV and V are views showing various stages in the maintenance of the surface.

The frequency of dragging is largely dependent on the traffic. Where there are long stretches of this type of road, subjected to several hundred vehicles per day, one-man patrol power graders are kept in continuous operation. The length of patrol varies considerably with the traffic, weather, material and other conditions. The cost of maintenance is also a function of the traffic and quality of material available. Where the traffic exceeds 600 vehicles per day the maintenance cost becomes excessive and the dust becomes a nuisance and a danger. Under these circumstances it will pay to adopt dust combative means. Success has been had with both calcium chloride and with bituminous materials.

Bituminous Surface Treatment

When the dust becomes objectionable and the maintenance cost excessive, one method of bituminous surface treatment which has been successful is to apply

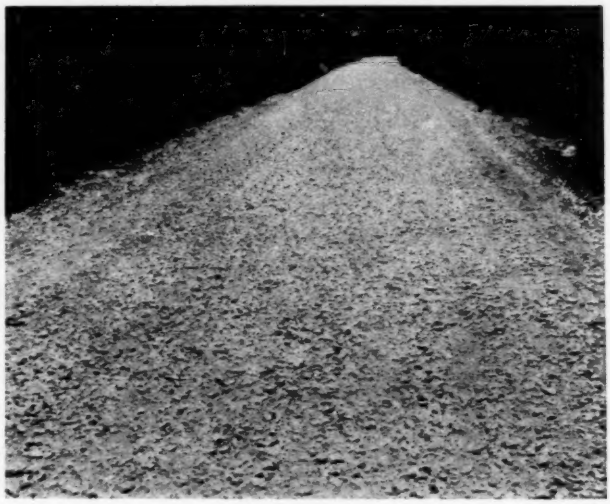

FIGURE II.
Stone Surfacing Ready for Blading.

first a prime coat of light tar, followed later with one-fourth gallon per square yard of heavy asphaltic oil, applied hot and covered with a good grade of stone chips at the rate of 25 pounds per square yard. This method has given excellent results and is inexpensive.

Wisdom of the "Stage Construction" Method

The method of road construction which progresses in

FIGURE III.
Windrow Left by Grader. Surface will be Smoothed during next passage of Grading Machine.

road type as a better surface is warranted by traffic, is known as "stage construction." This method has many

FIGURE IV.
One-man Power Grader, one of the types of equipment used for maintaining a smooth surface. A thin loose layer of stone is the ideal condition.

obvious advantages. In the first place, all of the benefits of excellent highway surfaces are provided and are distributed to the entire population within a remarkably short period and at very low cost.

The rapid development of the resources of previously isolated communities results as a matter of course. Land values probably will be increased and social, religious and educational facilities will experience an almost immediate growth. In time a higher type of road surface may be needed but the community will

FIGURE V.
A Well Maintained, Smooth Riding Surface.

then be in a much better position to finance such a surface. Meanwhile it is enjoying all the advantages of really suitable roads. When, finally, the period does arrive that the increased traffic requires still better surfaces, the subgrade will be in the best possible condition to support them. All of the weak spots will have been automatically disclosed by the action of traffic and will have been strengthened by maintenance through the dragging in of extra stone. Moreover, there is no better sub-base than a layer of compacted granular material, such as fine crushed stone, for a high type of surfacing, whether it be concrete or a road of the flexible type such as bituminous macadam or bituminous concrete. The best surfacings when built upon such a sub-base are much better fortified to withstand traffic than when laid on an untreated subgrade. It is really remarkable how a comparatively thin layer of small size stone or stone screenings will stabilize any kind of soil, either a plastic clay or a clean loose sand and many communities are already taking advantage of this fact.

In Fig. VI is shown a view of Davis Street, Danbury, Connecticut. This was originally yellow hard-pan, im-

FIGURE VI.
Davis Street, Danbury, Connecticut.

passable in Spring and Fall and subjected to severe frost action as indicated by the curb heaved out of place. In 1922 three inches of hard screenings were applied and maintained with calcium chloride. It is stated that this road has not heaved nor has it become muddy. It receives fairly heavy travel and is the route followed by a bus line.

Loose sand is also stabilized and hardened into splendid driveways by the use of 2½ to 3 inches of screenings. No rolling is required except that given by traffic. Under the action of traffic suitable screenings will compact to a smooth hard, surface that will support light traffic. A quarter of a gallon of light oil or calcium chloride sprinkled on the surface will effectively eliminate the dust.

Let it be emphasized that the above method of construction is only intended for light traffic in amounts not exceeding 500 to 600 vehicles per day. It will not replace the better classes of pavements and is merely one

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Mixed Macadam Type of Pavement

Paper Read Before The Fifth Asphalt Paving Conference

WASHINGTON, D. C.

By R. M. Smith, Chief Engineer, Department of Public Highways
Province of Ontario, Canada

The name "Mixed Macadam" is given to the type of pavement about to be described possibly for no other reason than the fact that there is a slight resemblance to ordinary macadam and secondly because no better name seemed to present itself.

Mixed macadam is the result of the insistent demand by the motoring public for a high type road which can be constructed rapidly and cheaply, and at the same time carry traffic while being constructed. It possibly would not be amiss here to explain, as briefly as possible, the road development in the Province of Ontario. Active construction started about the year 1919. Many miles of road in the Province previous to this had received a light treatment of gravel and although the roads were generally passable no attempt had been made to widen the grades, improve the alignment or cut down the hills. Since 1919 practically the entire system of Provincial Highways has been graded, many miles regravelled; the big percentage, however, being paved. Every mile built or paved has meant increased traffic, particularly tourist traffic. Every effort is made by the Province of Ontario to foster this class of traffic. During the year 1925, 1,290,000 cars from the United States crossed the Canadian Border via Ontario ports of entry. This year indications are that the traffic is at least twenty per cent. heavier, and next year when the main highway from Detroit in the West to Montreal in the East has been completed a much greater increase in traffic is expected. The Provincial standard calls for a road graded from shoulder to shoulder, 30 feet in width, the paved area 20 feet in width. At one time the Government considered the construction of pavement one-half at a time carrying traffic on the other half. The extra cost running frequently as high as $10,000 per mile, however, soon dissuaded Government officials from continuing this practice. The next difficulty was the finding and maintaining of suitable detours and finally we encountered the areas where detouring was next to impossible.

The Department maintains at the University of Toronto, a fully equipped highway laboratory. This laboratory is under the direction and guidance of an Engineer who is constantly in touch with the District Engineers throughout the Province. The exchange of ideas, both as to theory and actual practice has resulted in marked improvement in our Highway work. This year the Engineers on Provincial work were asked to design a type of pavement that would meet all the requirements of a high-class pavement and at the same time carry the traffic with little or no interference. Engineers, I may say, are given every encouragement along the line of experimental work, the Government being ready at all times, to investigate and develop any idea which is at all practical.

The development of mixed macadam followed as a result of our study of the construction of bituminous penetration surface. Bituminous penetration surface is, and has been accepted as a superior type of pavement capable of carrying very heavy traffic with light maintenance for many years. It is built in Ontario three inches in thickness on concrete or macadam base. The greater part of the stone used in the construction of this pavement is of a size that will be retained on a 1¾-inch ring but will pass 3-inch ring opening. This stone after light rolling is treated with bitumen, chinked with ¾-inch stone and rolled until thoroughly consolidated, the surface later covered with ⅝-inch chips. Two gallons of bitumen per square yard are used in the construction of this type of road. Experience has proven that the voids in stone in the surface are not entirely filled. A little mental calculation will also indicate that the bitumen will run at least 6 per cent, by weight, with a possibility that considerable stone is not covered. The Department has taken the stand that the success of bituminous penetration must be accepted. Granted that it is a success, why not improve on the type, by having in the first place all materials thoroughly dry, the stone used properly and evenly coated with bitumen? Why not fill the voids as far as possible? Why not take the entire quarry output, screenings included, thereby lessening the cost?

This year we are building as an experiment, 20 miles of

mixed macadam pavement, 13 miles of this length from local quarries and 7 miles from local gravel pits. In each case the pavement is being built, on what is accepted in Ontario, as a fair gravel road. The pavement is at present being laid in two courses, three inches each. The Department had in mind originally to lay the pavement in two courses, each course to be 2½ inches thick, the first section laid, however, had the appearance of raveling, and secondly, it was felt that the finished pavement, 5 inches in thickness, did not contain sufficient body to cover heavy traffic.

The method of construction is simple and definite. The selection of the quarry or pit is particularly important, it goes without saying that only the best of local material should be considered, the quarry materials given preference. Crushed rock with its angular shapes gives key and bond that can hardly be obtained with gravel. If possible to obtain a quarry near a railway siding, a further advantage is gained in that asphaltic materials can be shipped in tank cars rather than drums thereby saving several dollars per ton, and many dollars per mile of road.

The stone after leaving the quarry face is passed through the crusher, the oversize being recrushed if necessary, until all stone will meet the specification. The material is then conveyed by elevator buckets and belt conveyor to the drier, the flow of material being continuous, the object of this is to keep the stone mix consistent. The stock-piling of stone demonstrated the fact that the large pieces would roll to the outer edge of the pile, while the smaller sizes would work down into the centre of the pile. The stone after reaching the revolving drier is heated to 300° F., and thoroughly dried before reaching the hopper, it is then ready for mixing with the asphalt, which has been preheated in suitable melting kettles to a temperature equal to that of the stone. The materials, both stone and asphalt, are then properly proportioned by weighing and thoroughly mixed in a twin pug or batch mixer for a period of 45 seconds after which the mixture is conveyed to the roadway. It might be of interest to note here that the asphalt used is required to have a penetration at 77° F. 100 grams 5 sec. between 75 and 85.

The subgrade is prepared by scarifying, reshaping and rolling until thoroughly consolidated. On some of the work this year we have then placed a 3-inch plank along the edge of road with the thought that: First, it would give the finished pavement a better appearance, and secondly, it would be a guide to rake men to determine thickness of courses. Some of our district engineers object to this method, taking the stand that a sharp edge is left at the side of the pavement which must be protected by placing loose stone. They recommend as an alternative that the first course be laid 21 feet wide, the edge feathered off with the roller, the top course to be 20 feet with the edge treated the same way. Either method we believe, will give satisfaction.

The specification further provides that materials upon reaching the road must all be placed on boiler plates and then shovelled by hand into position, mechanical spreaders, however, are also permitted. This year some of the contractors used what is known as the Burch or Galleon spreader with good success. This spreader which is 8 feet long could also be improved upon by changing its design to prevent the larger stones from running to the edge and to the centre of the road, when half the road, or in our case ten feet, is being laid at a time. When the mechanical spreader is being used they are operated in pairs one slightly ahead of the other, this permits of traffic passing the spreader without hold up.

Each course as it is spread is thoroughly rolled with a ten or twelve ton roller until absolutely consolidated. The top course receives, however, just before final consolidation a coat of ⅜-inch chips, approximately 50 tons to the mile, but in any case, sufficient to fill all voids that appear in the surface. These chips are applied while the surface is still warm and are thoroughly rolled in during final consolidation. The road is then allowed to carry traffic for a period of from one to two weeks after which a surface of 60 per cent asphalt road oil, ⅓ gallon to the square yard is applied.

When first considering the construction of this type of pavement we had in mind the application of a squeegee coat immediately following the placing of the top course, the intention being, to use the same asphalt as used in building the pavement. The quantity of asphalt used, the slowness of application, and finally the non-uniformity of the surface appearance decided us to try the distributor method. We are still following this method with the exception that on one section we propose to try 80 per cent asphalt road oil. In any case, immediately following the surface treatment a second application of stone chips or pea gravel is applied, amounting to approximately 70 tons to the mile. The road is then completed.

It would probably be of interest to dwell for a moment before concluding on a few of the points that are outstanding in connection with the construction of this pavement. First, the equipment in the quarry, a crusher which will turn out 300 tons of stone per day is required, next, the asphalt plant must be of sufficient capacity to

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handle this quantity of stone. On the road two rollers can be used to advantage, an eight ton and a twelve ton, equipped with scarifier. Mechanical spreaders assist materally in the spreading of materials only five shovellers and two rakers being required to handle 300 tons per day. A foreman and one man to clean, grade and remove forms complete the personnel. At the mixing plant itself, four men and one team will be required, with 22 men and four teams operating the quarry. The mix as it comes from the plant should contain 95.2 per cent stone, grading in size from dust to 2-inch ring and 4.8 per cent asphalt, penetration approximately 77. Where a stone is being used which is lacking in "fines" up to 5 per cent sand may be used to advantage. So far we have accepted any fairly well graded sand. The material should have a temperature of approximately 300° F. as it leaves the plant in any case, arriving at the road at a temperature not below 275° F.

In the construction of a 20 foot roadway, 6 inches thick, 3,700 tons will be required to the mile, where slight depressions in subgrade are likely to be encountered 10 per cent must be added to this amount, or roughly 4,000 tons of material are required per mile of road.

All contracts are let on a tonnage basis, the contractor supplying everything but the asphalt, which is supplied by the Department. This year the average cost per ton for the asphaltic mix laid down in finished road was $4.80 per ton or $19,200 per mile.

The work of constructing a mixed macadam pavement is still in the experimental stage, with each mile we completed we improved the type. There is no question but that time will tell whether we have succeeded or failed, but certainly the appearance of the road surface is all that could be desired at the present time. We have also pleased the thousands of motorists who have passed over the road and instead of the usual caustic remarks as to detours and inconvenience we have received many letters of commendation. Taking it all in all, we believe the type of pavement we have discussed will be an absolute success and anticipate the construction of a very considerable mileage next year.

MEMBERS COOPERATE WHOLE-HEARTEDLY IN SAFETY WORK

The response to President Graves' letter of March 10 relative to our members' entering the 1927 National Safety Competition has been most gratifying, there now being forty-five quarries entered, representing fourteen of our member companies.

Although this is a decided improvement as compared to last year, nevertheless it is manifest that there are still a number of eligible companies which have not entered. As the value of the safety statistics which will be compiled from information sent in by the contestants is largely proportional to the number of entries, we wish to make one last plea to our members to immediately send in to the Bureau of Mines their applications for entry in this competition, blanks for which were attached to President Graves' letter of March 10. Should these have been mislaid, a request for additional blanks will receive immediate response from the Secretary's Office.

ANNUAL MEETING OF THE AMERICAN CONCRETE INSTITUTE

The American Concrete Institute held its annual meeting in Chicago, on February 22 to 24 and its program was replete with papers of very great interest to engineers, architects, constructors and producers of materials.

Of chief interest to crushed stone producers is the fact that an unusual amount of attention was devoted this year to the question of the influence of aggregates on concrete. A rather complete report was presented by Committee E-5 on Concrete Aggregates. It dealt fully with both gravel and crushed stone and promised more complete information on slag in its next report. R. W. Crum, of the Iowa State Highway Department, is chairman of this Committee. A paper of particular interest was read by Dr. G. F. Loughlin, of the U. S. Geological Survey on the durability of rocks as influenced by their mineralogical composition. He opened up a field of thought of very great importance to the crushed stone industry, especially at the present time since engineers are now seeking high quality and are inquiring more and more into the resistance of aggregates to weathering.

Prof. Herbert J. Gilkey, of the University of Colorado, showed that there is a surprising lack of knowledge on the effect of coarse aggregates on the properties of concrete. He showed that it is highly important to make investigations to determine the effect on concrete of size, shape of particle, nature of surface, durability, expansibility, etc. He indicates that all of these factors influence the strength of the concrete. Other papers and reports on concrete of very great importance to the industry were likewise presented.

The American Concrete Institute is an organization composed of engineers, constructors, materials producers and others interested directly or indirectly in concrete materials, concrete and its uses and in concrete design. It would be advantageous to all crushed stone producers to belong, for the annual proceedings are recognized as an authentic source of information on concrete in this country. Producers of materials with the exception of crushed stone producers are well represented in the membership of this organization. Crushed stone producers are really placed at a great disadvantage by not belonging. The Director of your Engineering Bureau will be glad to give you further information on the Concrete Institute, for he would like to see all of you become members.

The President's Page

For a number of years Mr. Goldbeck has been a prolific contributor to the current literature pertaining to road building and construction. Since he has assumed the duties of Director of our Bureau of Engineering his articles have been largely confined to publication in the Crushed Stone Journal and the Weekly Bulletin. Occasionally in this period he has written for several of the trade publications and his addresses before various technical bodies have been published in various quarters. We are of the opinion that to so largely confine his contributions to the subject in which we are all interested does not permit of that wide distribution of his thought which would be of interest and value to road building and construction agencies and to our own industry. We have had ample evidence that his articles are not only read by engineers of prominence, but that they attach considerable weight and importance to them. As we have previously stated, requests have reached us from time to time from highway executives for from fifty to a hundred copies of certain issues of the Journal for distribution to their staffs and co-workers.

To render his articles more available for general use, and to give to them a wider circulation in the interest of the intelligent advancement of construction in all forms, it has occurred to us that it would be proper and desirable for him to issue under his own name, and bearing the imprint of the National Crushed Stone Association, various pamphlets from time to time dealing with subjects of current interest. These pamphlets could deal with such subjects as "The Bulking of Sand and Its Effect on Concrete," "Improved Designs of Bituminous Road Construction," "Some Considerations in Concrete Road Design," "Significant Tests for Concrete," "Uses for Stone Dust," "Studies in Macadam Road Design," "Crushed Stone in Sewage Disposal Plants," "Limestone as a Fertilizer," "The Properties of Crushed Stone as an Aggregate" and others of which these are but indicative. We believe that such pamphlets would be of interest throughout the construction industry and would be worthy of and warrant a wide distribution among engineers engaged in all phases of building and construction.

For the Association to bear the entire expense of publication and distribution would involve a greater expenditure than our treasury is at present able to bear. It therefore seems feasible to propose that the Association during the coming year issue in quantity some eight or ten pamphlets, each dealing with subjects of the nature indicated, and sell them to our members or local associations at cost. Space would be provided on the title page for "Compliments of....." so that the recipient might know to whom he was indebted for the pamphlet. In this manner the cost would be very low, possibly six or eight cents for each pamphlet if ordered in sufficient number and the individual members or local associations could thereby make sure that the engineers in the field of their operation each received a copy.

Mr. Goldbeck is ready and eager to undertake this work and we believe that his doing so will be in line with our endeavor to serve the users of our commodity as efficiently and effectively as possible. It is probable that the first pamphlet will be issued at an early date. Order forms will be sent to each member and local association and it is hoped that they will be returned promptly in order that we may provide a sufficient number and yet not have any undue wastage.

We should be indeed glad to have any comment as to this procedure, whether favoring it or otherwise, suggestions as to details of the plan, and as to subjects to be treated. We firmly believe that by thus affording a wider distribution to Mr. Goldbeck's articles, we will be rendering a service to others, with reflected benefit to ourselves.

* * * * * *

At the time of this writing, March 28th, 47 of our members have returned the membership pledges, subscribing in total 393 individual memberships representing $9,825. Though it is gratifying to observe that the 47 firms reporting have fully subscribed to the basis of dues relative to tonnage as adopted at the Detroit Convention, it is highly unfortunate that the rest of our members have not replied. There is no apparent reason why more than two months after the adoption of this basis of dues only 23 per cent of our members have reported. The Association must have an assured income sufficient in amount to carry on the work we have undertaken and while we have no doubt that this will ultimately be the case, nevertheless the delay is disconcerting and unpleasant.

We again call to the attention of our members that they are not obligated to subscribe upon the basis indicated in our letter of February 8th, but that this table is put forth only as a guide as to the amount of the contribution and with the hope that the work of the Association has been such and holds such promise for the future as to induce pledges on the basis requested. If, however, the tonnage produced by any particular member is so large as to cause him to feel that he does not care to contribute annually as much money as would be indicated in the table by that tonnage, he is entirely free to pledge such lesser amount as he deems advisable.

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Further, even though any of our members, for reasons good and sufficient unto themselves, do not propose to increase their contributions as compared to last year, it is none the less incumbent upon them to return the forms sent them, indicating the amount of their pledge, even though it is the same as last year.

Our dues are now payable semi-annually in advance on January 1st and July 1st, and this year proper credit will be allowed for dues already paid. We should have billed a month or more ago all of our members for dues from January 1st to July 1st, allowing the proper credit for payments already made; but we have been unable to do this for those of our members who have not returned the pledge forms. The Association needs a reasonable revenue in order to function effectively and its work cannot be maintained on hope and words of good cheer. I am personally of the opinion that those of our members who have not made returns have overlooked the matter or have not been sufficiently impressed with the necessity confronting our Secretary of sending out billing and his inability to do so until he knows the amount of the pledge, whether more, the same or less than last year. We urgently ask that all of our members who have not done so will immediately see that proper returns are made.

LOW COST IMPROVEMENT OF EARTH ROADS WITH CRUSHED STONE

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step leading up to the higher type which traffic may finally require. It, however, is performing splendidly and economically over several thousands of miles of lightly travelled highways, driveways, and entrance roads, and, undoubtedly, there are hundreds of thousands of miles of unimproved roads and driveways upon which the dry or "salting down" method of maintenance could be used with entire success. The policy of "stage construction" pays.

The following has been stated by Thos. H. MacDonald, Chief of the United States Bureau of Public Roads.* "Highways are a thing of service. Service requires changes; they must themselves change, and to provide adequate service over the largest possible mileage and at the least cost is the requirement just now, and there is abundant evidence that this has always been the policy when efficient highway service was required over a large area.

"This building up under service, only another name for stage construction, has always prevailed. Our roads must be maintained and strengthened, certainly and constantly, but this has always been the case. * * *"

*"Two Thousand Years of Road Building," by Thos. H. MacDonald, presented before annual meeting of the American Association of State Highway Officials, Pinehurst, N. C., November, 1926.

STATES PLAN ENORMOUS EXPENDITURE FOR HIGHWAYS IN 1927

Road construction during 1927 in 47 states will total 26,841 miles and will cost approximately $648,483,000. according to state highway programs reported to the Bureau of Public Roads, Department of Agriculture.

Expenditures of counties and other local subdivisions of government will total approximately $421,000,000 on road improvement, bringing the total well above $1,000,000,000. The full text of the detailed announcement of state plans follows:

The construction of 26,841 miles of road and the maintenance of 239,847 miles are included in the 1927 state highway programs of 47 states, according to reports received by the Bureau of Public Roads. The programs also include the construction of a number of large bridges and the reconstruction of roads previously improved. On account of uncertainty of supporting legislation no estimate of the season's work is possible as yet in Connecticut.

In carrying out the above programs it is expected there will be expended under the supervision of the state highway departments in the 47 states a total of $648,483,000.

In addition to the state expenditures approximate estimates indicate that counties and other lesser subdivisions of government will expend during the year $475,000,000.

Of the expenditures by the state highway departments of the 47 states approximately $421,000,000 is the estimated amount for road construction and, according to present plans, more than $56,000,000 additional will be spent for new bridges. For reconstruction of existing roads it is estimated that the expenditure will be nearly $27,000,000 and for maintenance approximately $126,000,000.

The mileage of new state highway construction contemplated during the year is given below:

Alabama, 406; Arizona, 100; Arkansas, 580; California, 80; Colorado, 124; Delaware, 75; Florida, 775; Georgia, 506.

Idaho, 145; Illinois, 1,255; Indiana, 415; Iowa, 1,090; Kansas, 1,598; Kentucky, 900; Louisiana, 500.

Maine, 414; Maryland, 124; Massachusetts, 240; Michigan, 415; Minnesota, 1,007; Mississippi, 524; Missouri, 922; Montana, 251.

Nebraska, 1,310; Nevada, 149; New Hampshire, 100; New Jersey, 120; New Mexico, 179; New York, 1,006; North Carolina, 650; North Dakota, 1,042.

Ohio, 850; Oklahoma, 850; Oregon, 252; Pennsylvania, 1,300; Rhode Island, 44; South Carolina, 600; South Dakota, 450.

Tennessee, 529; Texas, 1,800; Utah, 100; Vermont, 110; Virginia, 225; Washington, 385; West Virginia, 425; Wisconsin, 1,569; Wyoming, 350.

Total, 26,841.

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THE ROAD

From the path out of Eden to Calvary and the Marne the road has decided the course of Empire. The road and "an untimely cloud," led Napoleon from Marengo to Moscow, Waterloo and St. Helena and redrew the map of the world. There never was war it did not umpire. With blood it wrote the Armistice and sat at the head of the table when the treaty of peace was signed.

Ships, soldiers, statesmen, presidents, priests, potentates, congresses, kings and courts are its vassals. It never sleeps. Will never surrender and will never die. It is the boon companion of rich and poor and the high priest of prosperity. Its mandate changes not. Its banner is Excelsior and whether in frigid zone or torrid tropic it is the help and hope of efficiency and the precursor of universal peace.

Over it the World's scepter passed from Persia, Greece, Italy, Great Britain to the mighty west—here to remain, for there is no further west and there will be no road beyond.

J. W. Parmley, South Dakota Highway Commission.

MINING OF LIMESTONE GAINS IN FAVOR

A marked tendency toward producing larger tonnages of limestone by mining methods instead of by the old-established quarrying practices is very evident in the United States, the Bureau of Mines, Department of Commerce, points out in an announcement just issued by the Department. The full text follows:

In the course of six months' time during which the subject was investigated by the Nonmetallic Minerals Experiment Station of the Bureau, at New Brunswick, N. J., the number of underground limestone mining projects was doubled. Some of these limestone mines are quite large, the maximum daily production f om a single mine being 3,500 tons.

The enormous and constantly increasing demand for limestone to supply a multitude of uses is a remarkable feature of the mineral industries, states J. R. Thoenen, consulting mining engineer, Bureau of Mines, in a report on the subject. As approximately 130,000,000 tons of limestone are produced annually in the United States, it is not surprising that deposits at or near the surface are gradually being exhausted and that less advantageous supplies are being worked. Quarries are becoming deeper and wider year by year, and in many places the volume of overburden that must be removed to allow open-pit work is tremendous. Quarrymen are also gradually learning how expensive it is to sort and clean stone from a deposit overlain by poor material.

Resort to Mining Noted

As such conditions confront the limestone industry, the natural tendency is to seek some modification in method whereby the handicaps of increasing cost may be met and overcome. Operators, some of them unwillingly, have been forced to conclude that underground work in drifts and tunnels is the most logical solution of the problem. The unwillingness of some is largely due to unfamiliarity with mining and to the unfounded fear that costs must increase and dangers multiply when mining is undertaken.

The advantages of underground limestone mining are summarized by Mr. Thoenen as follows:

Removal of large masses of overburden is avoided.

A mine may be operated the year round, irrespective of weather conditions, thus affording steady employment to workers and promoting contentment in the personnel and a low labor turnover.

Under certain conditions storage facilities can be provided underground more easily than on the surface and without deterioration of the product. The surplus produced when the demand is slack can be stored in anticipation of peak demands.

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The clean stone produced at mines often commands a higher price than quarried stone. In fact, cleaning, at considerable expense, is often necessary to make the quarried product salable. Moreover, the limestone strata in mines are not exposed to the action of frost or water or mud washed from a clay overburden.

Mined Stone Declared Cleaner

For fluxing, mined stone is cleaner both in lump and fine sizes than quarried stone.

A mine can be advanced to property lines regardless of such factors as extent of overburden, dip of strata, cavities, and surface conditions. Moreover, mines can be worked within city limits, where quarrying might be dangerous or be forbidden by ordinances.

The disadvantages of underground limestone mining may be thus summarized:

Some means of ventilation must be supplied to carry off fumes from explosives and furnish fresh air to workers.

There is danger from falling rock.

More fines are produced than in a quarry.

The type of labor required is more skilled, and therefore more expensive, than quarry labor.

Costs are in general higher than for quarries, but the difference may be counterbalanced by the higher quality of the product.

Limestone mining is a comparatively young but rapidly growing industry. Mining methods are applicable to all deposits underlying overburden that is too heavy to be removed or handled by open-pit methods. Factors that make mining possible are the presence of enough stone to warrant the expense of development, stone of a grade to satisfy market requirements as to quality and price and also strong enough to make adequate pillars Strong roofs formed either by the stone itself or by overlying stratum are requisite.

Different Methods Used

Various methods of mining adapted from coal-mine. metal-mine, and open-quarry practice are in use as well as combinations of all three methods. The same statement applies to the placing of drill holes. The types of equipment used underground are much like those in use at open quarries, except that churn drills cannot be used.

There does not appear to be any greater danger in limestone mining than in metal mining if work is properly planned and carefully supervised. As many quarrymen lack information on mining methods, limestone mines need more skilled men and better technical direction than quarries. Although average mining costs are higher, many individual mines operate at lower cost than many open quarries.

The choice between mine and quarry depends upon local conditions, and a decision should be made only after careful study.

Results of a comprehensive investigation of underground limestone mining are contained in Bulletin 262, copies of which may be obtained from the Bureau of Mines, Department of Commerce, Washington, D. C.

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